# Space Weather Technical Forecast

Issued on Thursday, 21 March 2024 at 01:12 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: M-flares likely (R1-R2 Radio blackouts), slight chance of X-flares (R3 blackouts). Chance of G1/Minor Storm intervals from CME arrivals early Day 1 (21 Mar).**

## Analysis of Space Weather Activity over past 24 hours

**Solar Activity:** Activity has been Moderate, with the largest flare an M7.4 peaking at 20/0736 UTC from AR3615 in the southeast. There are currently nine sunspot regions on the visible disc. The two regions of most interest are AR3614 in the northeast (likely ex-3590 from the previous rotation which gave three X-flares, including X6.3 the largest of the solar cycle so far) and AR3615 in the southeast. AR3614 has a large main spot with a clear delta configuration, whereas AR3615 has a number of smaller spots, but is showing a couple of delta regions and has been responsible for most of the observed flare activity. AR3617 is continuing to appear around the southeastern limb with a new spot region, as yet unnumbered, rotating around the northeastern limb. Both will continue to be re-assessed as they become more clearly visible. A second new unnumbered region has formed to the east of AR3607, but is currently fairly small and simple. The remaining regions currently appear stable or showing slight decay.

No Earth directed CMEs have been observed in the last 24 hours.

**Solar Wind / Geomagnetic Activity:** Solar winds as observed by DSCOVR at L1 were initially just about slightly elevated around 400 km/s, but have since dropped to ambient levels, steadying at around 310-330 km/s. Density was around average or below. Interplanetary Magnetic Field (IMF), Bt, was weak throughout, staying at 6 nT or below. The north-south component, Bz, varied weakly between +5 and -4 nT. Phi was generally variable. Geomagnetic activity was Quiet (Kp1-2).

**Energetic Particles / Solar Radiation:** GOES18 high energy (greater than 10MeV) proton flux is close to background levels after the S1 enhancement on 15-16 Mar. High energy electron flux (greater than 2MeV) observed at GOES16 was at background levels. The observed 24-hour fluence was below the Active threshold, with a value at 21/0001 UTC of 1.15e6 integrated pfu.

## Four-Day Space Weather Forecast Summary

**Solar Activity:** Moderate activity is likely with a slight chance of becoming High with any isolated X-flares, mostly due to AR3614 and AR3615, but regions in the west still bear keeping an eye on.

**Solar Wind / Geomagnetic Activity:** A complex filament eruption on 17 Mar saw two possible Earth-directed CMEs. The arrivals of these are expected early on Day 1 (21 Mar), perhaps arriving as two separate shocks but may also arrive together. The more likely impact is from the slower of the two CMEs, but perhaps also a glancing blow from the slightly faster and further south CME. Ongoing effects are possible through the rest of Day 1, before then easing. A coronal hole fast wind from CH12/- may cause a further enhancement later on Day 4 (24 Mar).

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Geomagnetic activity is expected to be Unsettled at first. with a chance of Active or G1/Minor Storm intervals (Kp4-5) early on Day 1 in association with the filament eruption CME from 17 Mar, as well as a slight chance of G2/Moderate Storm conditions (Kp6). Effects are then likely to decline later on Day 1, becoming largely Quiet for Days 2-4 (22-24 Mar). Towards the end of Day 4 a coronal hole fast wind may connect with Earth, with geomagnetic activity possibly becoming Unsettled-Active (Kp3-4).

**Energetic Particles / Solar Radiation:** High energy (greater than 10 MeV) proton flux at GOES18 is expected to remain around background levels, with a slight chance of further enhancements. This risk increases slightly through the period as AR3614 and AR3615 rotate towards centre disc. High energy electron flux (greater than 2MeV) is expected to persist at mainly background levels with the associated 24 hour fluence remaining below the Active threshold.

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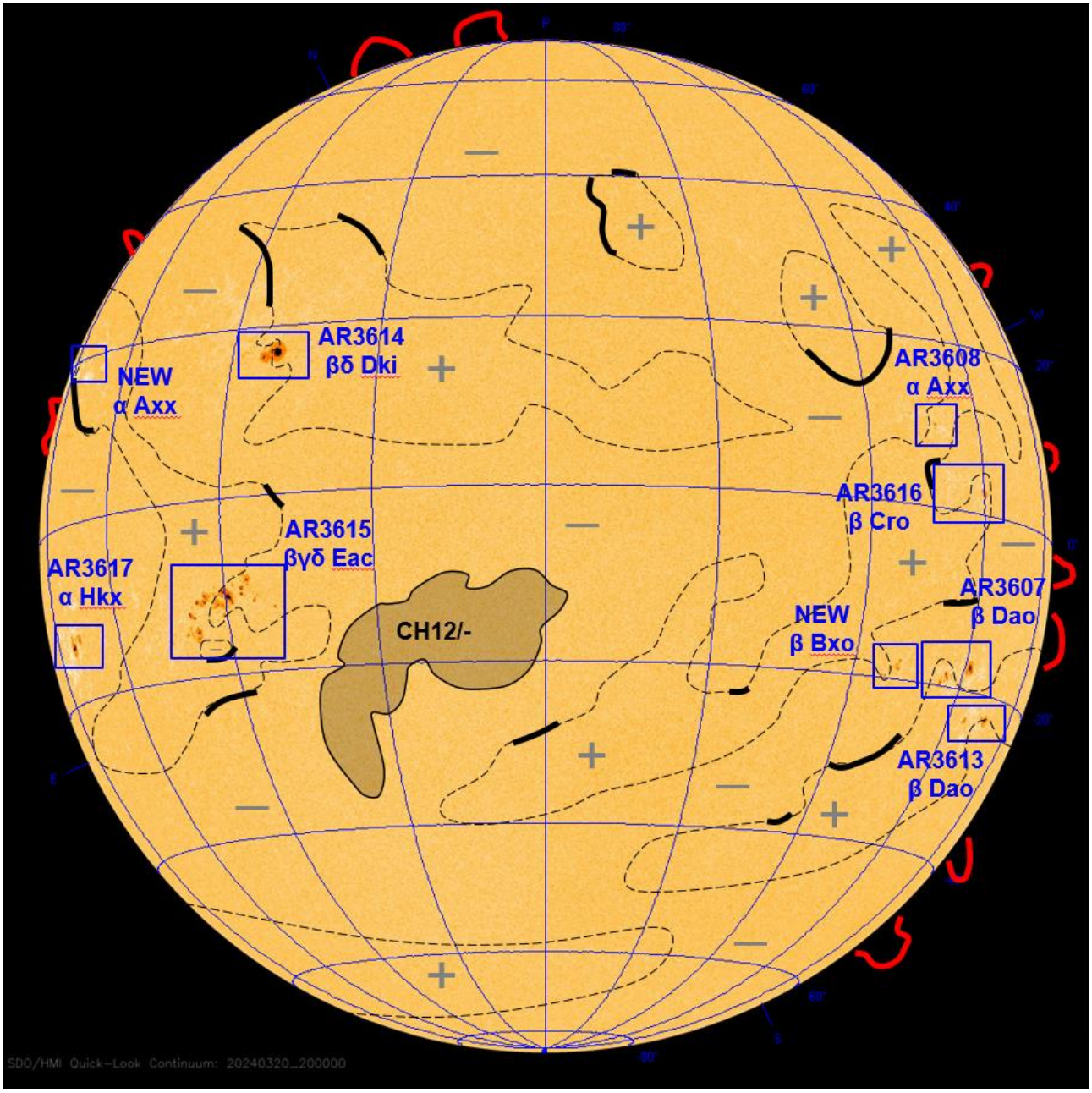
**Figure 1. Solar Analysis Valid 20/2000 UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms:

A CME was observed from a filament eruption from the southeast disc, occurring near AR3613 at around 17/0230 UTC. This is a complex eruption, splitting into two separate CMEs. The first one went to the southeast, and is faster, narrower but brighter on imagery, possibly giving a glancing impact. The second to the southwest is fainter, slower and wider, and consequently more likely to be observed arriving at Earth. Both are forecast to arrive early on Day 1 (21 Mar), with ongoing effects possible through the day, before then easing.

Coronal hole CH12/- is located near to centre disc, and may cause an enhancement in solar winds later on Day 4 (24 Mar). On its previous rotation this coronal hole saw solar wind speeds of around 450 km/s, with similar speeds expected once again, however there was little in the way of geomagnetic activity. As we are currently now around the Spring Equinox, negative polarity coronal holes will give more intense geomagnetic activity, so some enhancement is possible this time.

Geomagnetic activity is expected to be Unsettled at first. with a chance of Active or G1/Minor Storm intervals (Kp4-5) early on Day 1 in association with the filament eruption CME from 17 Mar, as well as a slight chance of G2/Moderate Storm conditions (Kp6). Effects are then likely to decline later on Day 1, becoming largely Quiet for Days 2-4 (22-24 Mar). Towards the end of Day 4 a coronal hole fast wind from CH12/- may become effective, with geomagnetic activity possibly becoming Unsettled-Active (Kp3-4).

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 40 | 1 | 1 | 5 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| 17/1035 | Partial | Filament | SW, near AR3613 | 505 km/s | Early 21 Mar | Moderate confidence. Perhaps preceded by glancing blow. |

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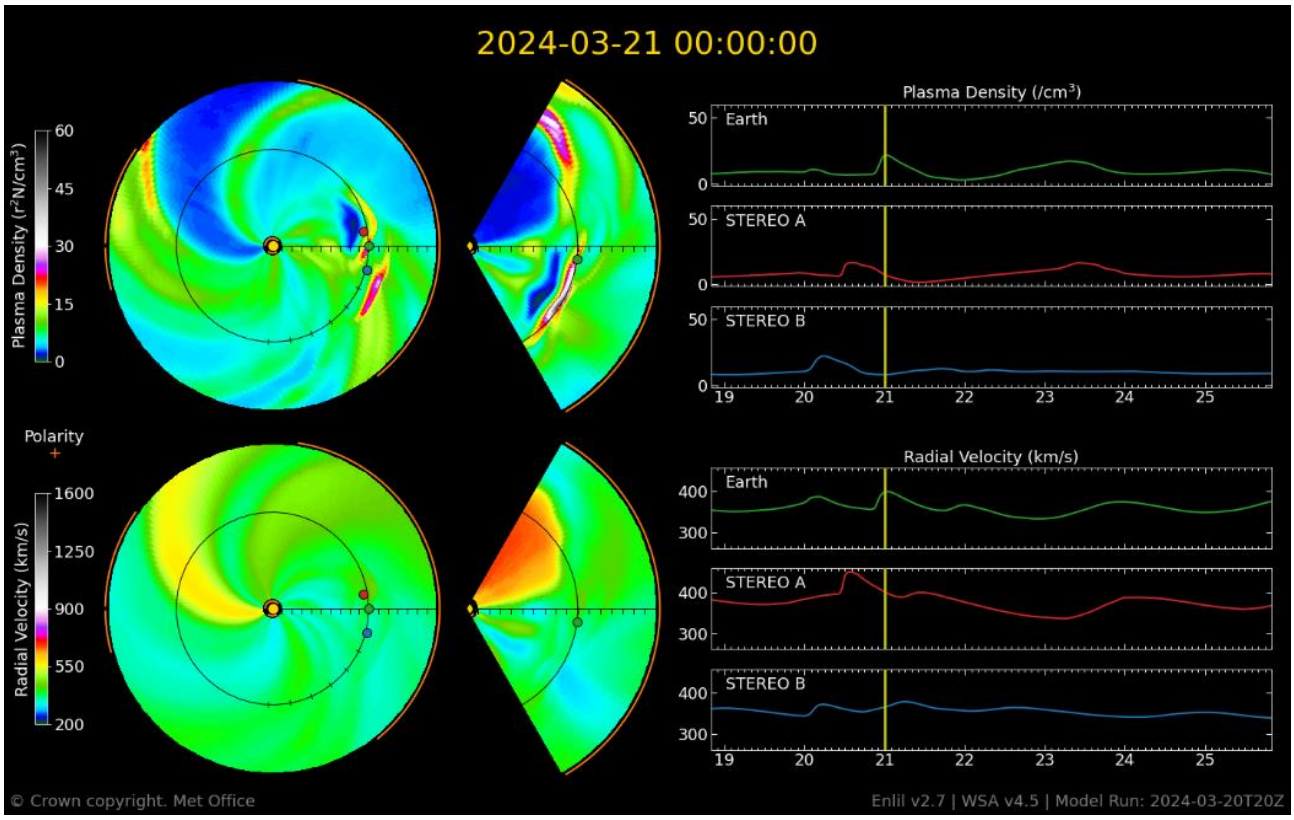
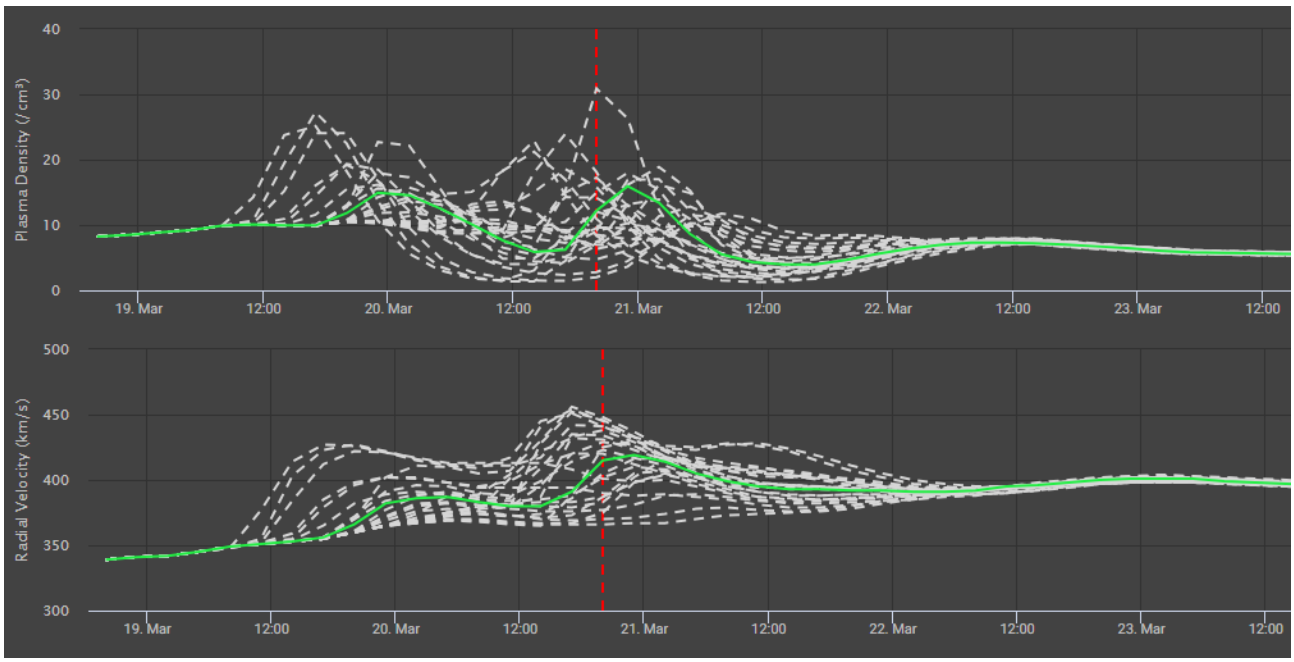
**Figure 2: MOSWOC Enlil and Ensemble, showing CME arrival around start of 21 Mar.**

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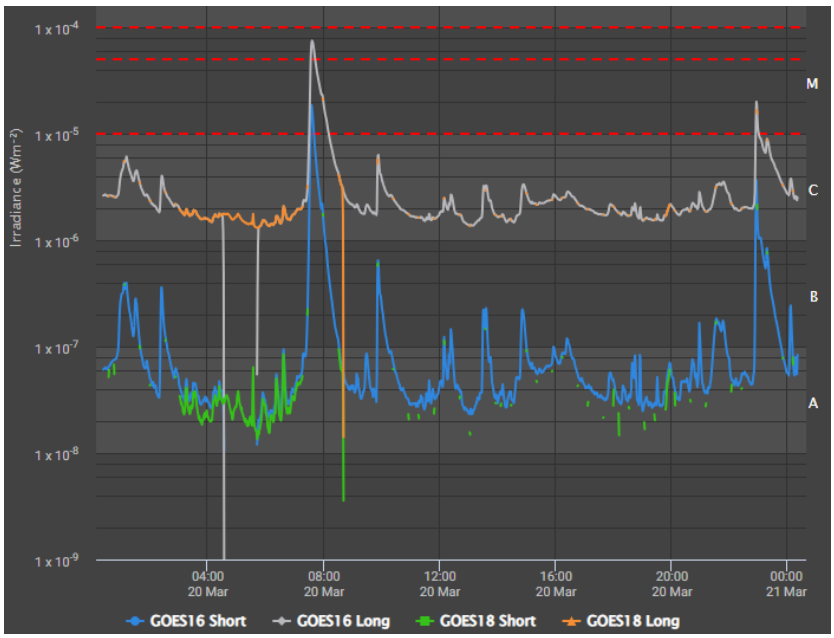
**Radio Blackouts - X-Ray Flares:**
Activity has been Moderate, with the largest flare an M7.4 peaking at 20/0736 UTC from AR3615 in the southeast.

There are currently nine sunspot regions on the visible disc. The two regions of most interest are AR3614 in the northeast (likely ex-3590 from the previous rotation which gave three X-flares, including X6.3 the largest of the solar cycle so far) and AR3615 in the southeast. AR3614 has a large main spot with a clear delta configuration, whereas AR3615 has a number of smaller spots, but is showing a couple of delta regions and has been responsible for most of the flare activity observed. AR3617 is continuing to appear around the southeastern limb with a new spot region, as yet unnumbered, rotating around the northeastern limb. Both will continue to be re-assessed as they become more clearly visible. A second new unnumbered region has formed to the east of AR3607, but is currently fairly small and simple. The remaining regions currently appear stable or showing slight decay.

Moderate activity is considered likely with a slight chance of becoming High from any isolated X-flares, mostly due to AR3614 and AR3615, but other regions in the west are worth watching too.

| X Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 M Class | Yes | 60 | 60 | 60 | 60 |
| Very Active | R3 to R5 X Class | No | 10 | 10 | 10 | 10 |

**Figure 3: GOES16 & 18 X-ray flux, showing M7.4 flare from earlier 20 Mar**

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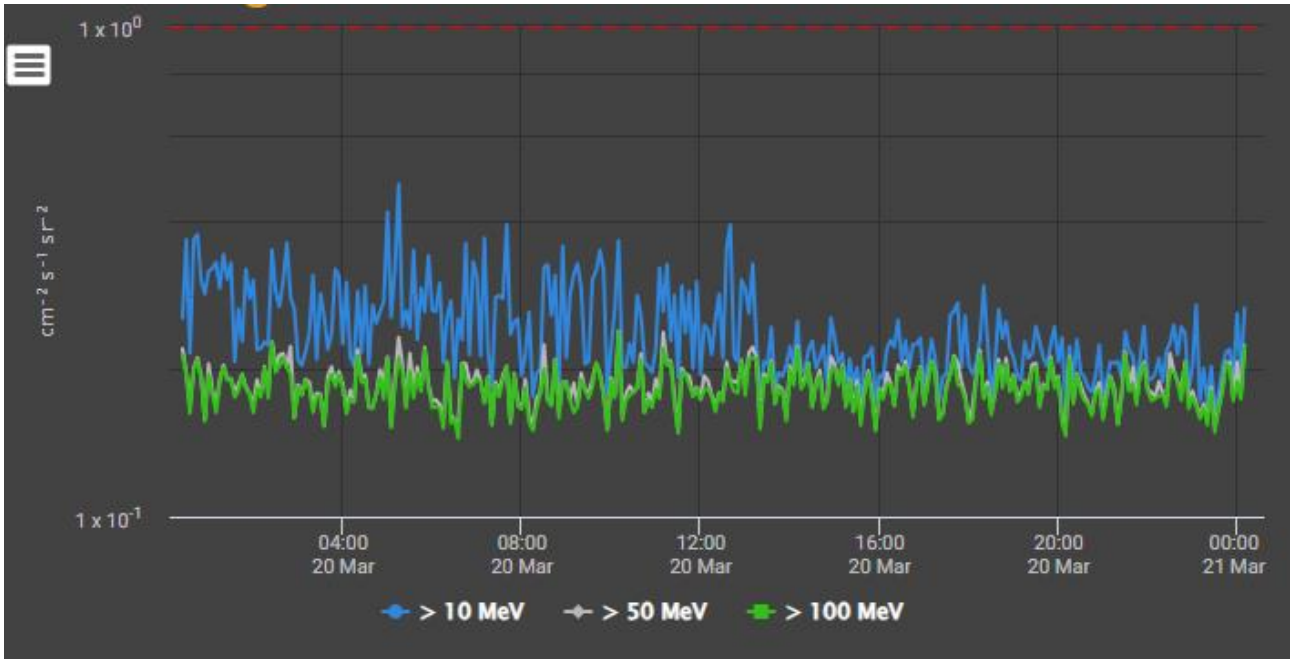
**Solar Radiation Storms - (High Energy Protons):**
High energy proton flux, as observed by GOES-18 is currently at background levels after falling since the S1 event on 15-16 Mar. Flux is expected to remain at or close to background at first, with further enhancements unlikely. As AR3614 and AR3615 rotate towards centre disc through the period, they move into a slightly better location for proton events to reach Earth and the probability of reaching S1 rises a little.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 5 | 10 | 10 | 10 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

**Figure 4: GOES18 Proton flux**

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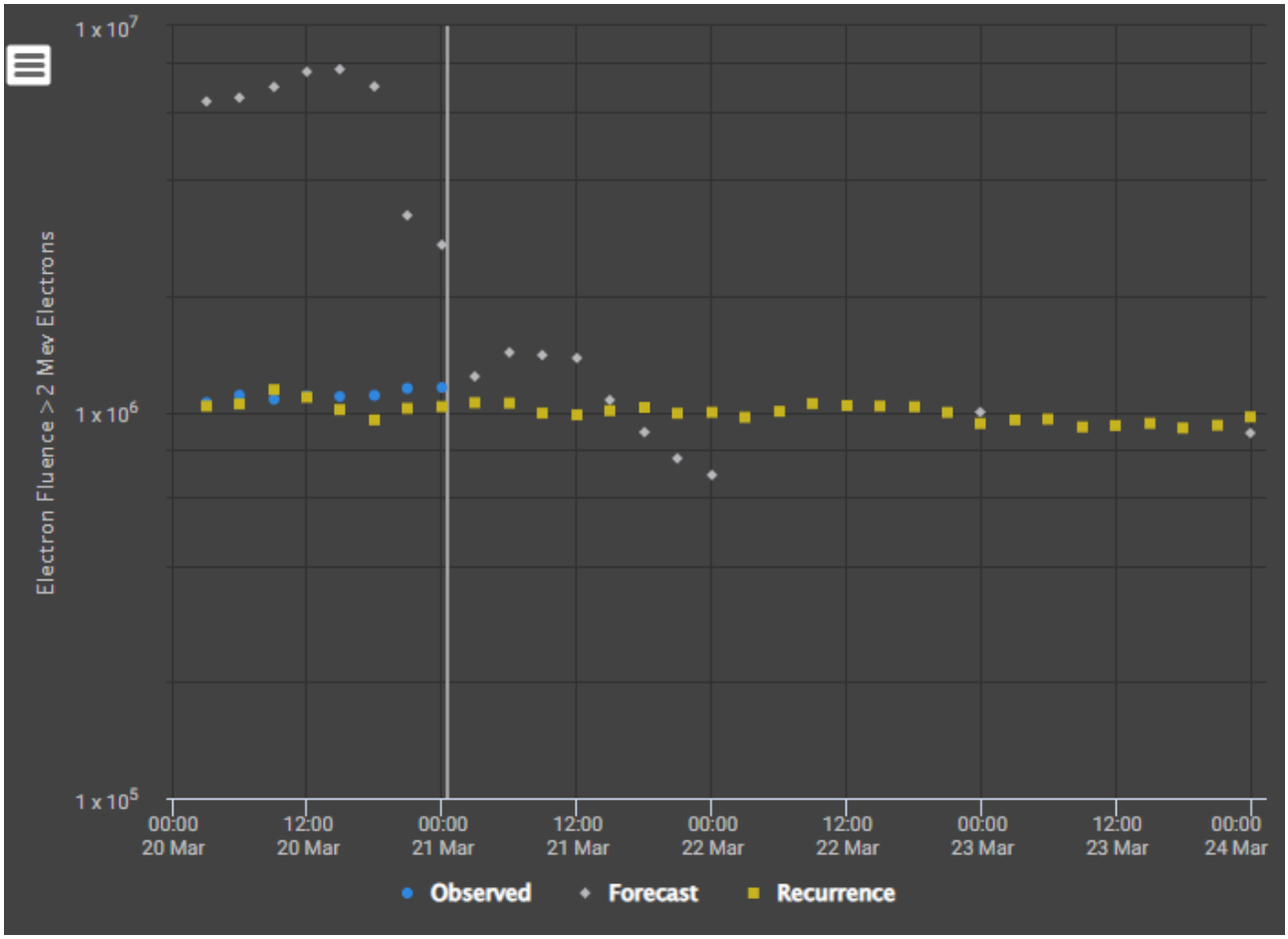
**High Energy Electrons Event (≥ 2MeV):**
GOES-16 electron flux is expected to remain at mostly background levels, with no significant sources of enhancement expected. A CME arrival is probable early on Day 1 (21 Mar), however this isn't expected to have a large impact at Earth. After the CME influence eases off a rise in electron flux is possible as the van Allen belts expand back out again, but unlikely to be significant.

As a result, the associated 24 fluence is expected to remain below the Active threshold, albeit with a very slight rise in probability through the period.

| GEO Electron Environment<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 1 | 5 | 5 | 5 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

**Figure 5: GOES16 REFM model, showing a below Active trend through the forecast period, which is considered good guidance.**

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